PORTFOLIO MANAGEMENT FOR THE COMMERCIALIZATION OF ADVANCED TECHNOLOGIES

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I. Introduction

This paper describes the validation of one aspect of the Value Creation Model (VCM) that Lucent's Advanced Technology (AT) group has developed and applied to research driven innovation projects. This aspect is the Rate/Productivity Metric (RPM) that is used to quantify and understand the expected present value of financial return of each project. The RPM includes estimates of the future dollar returns along with the risk associated with these returns thereby enabling the calculation of an expected value of returns. Uniform use of this metric allows management to analyze the collection of projects uniformly as a portfolio system which aids in the decision making purposes.

RPM is a metric and in order for any metric system to assist a decision maker, the metric must be able to demonstrate its validity to management. For a risk metric, one necessary validity test is the correlation between risk and corresponding reward. This is especially true of a metric design to delineate the value provided to the corporation by a portfolio of research driven innovation projects.

Risk in R&D can come from multiple sources such as technology, staff capability, marketing, and resource availability/commitments. The RPM, in its present implementation, measures risk as a summary estimate of all these sources combined. Given the summary form, validity of the RPM needs to be established to assure the developers and management that the metric has been properly developed.

Any investment risk model is expected to show a positive relationship between the magnitude of expected payoff and the degree of risk. Unless such a correlation can be demonstrated, the metric is not likely to be useful as input to the management process.

II. Background

The development of an appropriate productivity measure for research driven innovation projects and the ability of managers to apply that measure meaningfully to a portfolio of projects so as to accurately portrays the R&D risk reward frontier has proved elusive. Many firms revert to relying on short term financial measures that evaluate the performance of their organization in terms of net present value. For long lead time R&D projects, the discount factors on returns expected in five to 15 years from now weaken the use of such conventional tools. Other firms simply forgo the effort to develop meaningful measures to support their R&D processes. Still others have reacted by radically changing the charter of their R&D organization or by eliminating their internal R&D function altogether.

These extremes are fueled on one side by those who suggest that no short term financial metric is suitable and therefore cannot aid in managing any portion of the R&D process. Simple stated "ROI is not enough" (Mechlin and Berg 1980). These practitioners and academics argue that the R&D process is too eclectic, very difficult to meaningfully measure on any basis and difficult if not impossible to justify by financial analysis alone. These professionals perceive that calculating discounted cash flow or ROI in order to manage the R&D process more effectively is simply adding guess work on top of uncertainty. Given these assumptions, it is not unusual for R&D organizations to operate as cost centers and are treated as such in management decision making.

Others counter with the quality dictum "If you can't measure it, you can't manage it. If data does not exist to support a measure, the management process for a key strategic objective is likely to be inadequate or non-existent" (Endres 1997). Further,

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they argue that the language of management is money and that sooner or later R&D must measure up to that same standard. This too has a ring of truth but the operative questions that guide the management of the research driven innovation process must become: What should we be measuring? How should these factors be measured? Can these measures usefully be applied across a portfolio of R&D projects? And: "How can financial risk and reward be measured within our management model?"

Lucent Technologies has faced this problem squarely and dedicated a team of Bell Laboratories scientists to the task of creating a decision support system that allows management to measure and make informed decisions about its Advanced Technologies (AT) Group R&D operations. The overall model is called the Value Creation Model. One component of this model is the Risk/Productivity Metric (RPM). This paper describes the nature of the RPM and how it was validated.

This paper displays our model and our metric. However, it focuses on the developed and tested RPM metric portion in order to discuss the relationship between risk and reward in the decision support system utilized to assist in the management of R&D at Lucent's Bell Labs AT group. Our model and metric has been applied to a portfolio of 522 projects that provide over two years of data. We first provide a visual display of our interactive model. We then discuss the RPM metric and our summary measure of risk and finally we test for the relationship between risk and reward in our portfolio of research driven innovation projects at Lucent's AT division.

Briefly the measurement of risk in this decision support system is made by computing the variance of future expected returns. Our risk measure utilizes a standard deviation measure of risk but has interactive real time visual links allowing the decision maker to investigate various parameter interactions in order to understand the portfolio's adherence to an efficient risk reward frontier. This can be done for either the portfolio of projects, segment thereof, or any particular project in that portfolio. In our model risk is expressed numerically but modified by the visual interactions that allow the manager to alter the focus and type of projects in the portfolio. This enables subset portfolio risk reward paradigm analysis.

III. The VCM Model

The Lucent Value Creation Model (VCM) for AT projects possesses five characteristics and four primary attributes which embody many of the key findings that R&D researchers have identified as important. The essence of the model is a decision support tool that provides visual displays of the key factors of the research development process. The VCM provides no "right answers" but rather allows decision makers to visualize the interactive relationships among projects and their attributes through a interactive visual display of many complex and competing management imperatives.

The objectives guiding the creation of the VCM model are:

- The model must have a forward looking focus, not past;
- The process is to be used to baseline and set objectives;
- The model must be easy to understand to all members of the organization;
- The process must link to corporate strategies;
- The model must include important factors associated with all the objectives of R&D such as developing leading edge technologies or competence development.

These goals led to the definition of four key factors that need to be explicit in the RPM metric: cost, revenue, time and risk. In addition a set of five categories of attributes and other factors that operationalize the organization's goals were defined. These attribute categories and attributes are;

- Business units - The Lucent Business Unit(s) involved with each project are identified.
- Intellectual property - Two aspects of the intellectual property characteristics of each projects are measured.
- Technologies - Two measures of the character of the technologies applied are measured.
- Markets – The market addressed by the project as well as the life cycle of the product are captured.
- Strategic initiatives - Each project is related to Lucent's strategies.

The selection of these characteristics, factors and attributes provides a path for measuring R&D quality. As noted by Enders (1997) ". . . measurement pyramids for R&D organization include: portfolio evaluation, numbers/ quality/ functionality of resources." These goals link R&D directly to the overall corporate strategy providing a: "Balanced scorecard perspective: financial, customer, internal business processes, learning and growth." (Kaplan

1996) Further, the implementation of this model has helped initiate a cultural change at Lucent AT. Ron Jetko a CFO at Lucent AT states "...R&D labs' scientists are now required to think in terms of research projects' relevance to corporate strategies and their projected contributions to the bottom line"

The VCM system allows management to easily identify these projects and ask important R&D planning questions such as: Should project funding be shifted toward the high-value low-risk quadrant? Are too many projects in the low risk, low value quadrant? Admittedly, there are many considerations involved in answering these questions. But, the VCM allows Lucent management to visualize the relationships among the nine attributes described above as part of the planning process.

Figure 1 shows one view of the VCM visual outputs that displays output relationships of ten projects across eight attributes. Here each column identifies all the projects. The linkages as shown by the yellow lines and nodes are the specific subset of

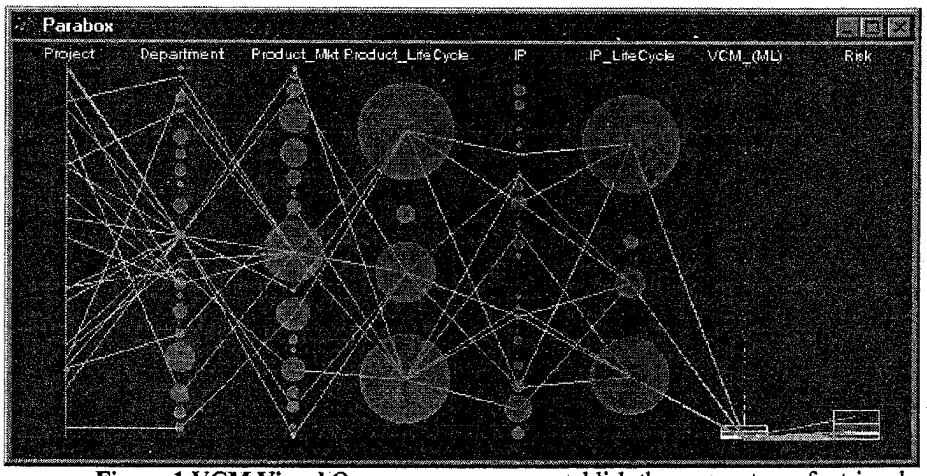


Figure 1 VCM Visual Query

projects we are inquiring after. Each column is an attribute and each line is a project. The area of the circles describes characteristics of the attribute. For example, under product life cycle, the relative sizes of the circles represent the distribution of the projects in the portfolio by product life cycle.

This model does not make a decision. However, the VCM promotes inquiry and stimulates discussion that focuses management attention on multiple attributes rather than myopically using ROI as the sole decision criteria. Nonetheless, the RPM can be accessed separately to provide a comparison of expected financial return among projects.

IV. The Risk/Productivity Metric

The RPM portfolio metric is a simple benefit-cost ratio. It is the ratio of expected future incremental cash flows resulting from the project attributed to the incremental R&D expense. The cash in flows and expense out flows are computed at the corporate level. The metric is named the "Risk Portfolio Metric" or RPM.

(1) RPM =NPV (Net corporate incremental cash flow) / NPV (R&D's incremental investment)

A. Risk Calculation

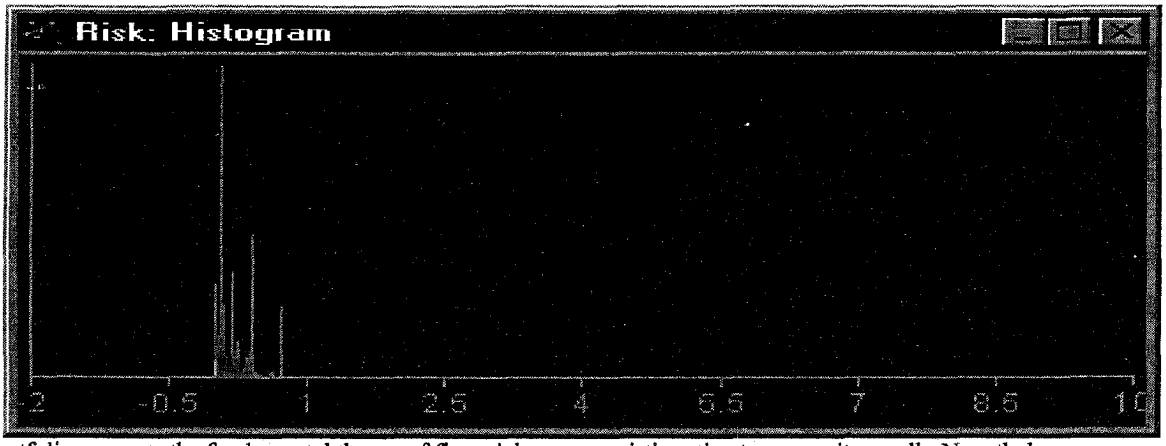
We measure the risk in our portfolio and quantify the riskiness of the individual projects in the portfolio through a series of project generated cash flow estimates. Project managers prepare a pessimistic, realistic and optimistic estimate of cash flows from each project. The three estimates are used to establish the parameters of a triangle distribution that is then used as the measure of risk. For purposes of comparing across projects, individual project risk is computed as the normalized standard deviation of the triangle distribution (Winston 1996). The character of risk in Lucent AT's risk can is visually displayed by the histogram projected by the VCM shown in Figure 2. Here again we can compare our selected ten projects in yellow with respect to the portfolio as a whole. The x axis is the normalized standard deviation and the y axis is number of projects.

B. Testing the Model: The Risk Reward Relationship

Using our definition of project risk and the project RPM as a proxy for expected project return or

corporate value we can construct a basic RPM-risk scatter plot. We check to determine if our project

Figure 2: Histogram of Risk Normalized Standard Deviation vs Number of Projects



portfolio supports the fundamental theory of financial portfolio management which roughly states that expected return is directly proportional to the risk of the return (Brealy1980). We accomplish this by regressing the project RPM values against the project risk. A positive regression coefficient with a strong t-statistic is an indication that in general the riskier projects in our portfolio are expected to have the higher returns.

The regression had a t-statistic value of 4.43 and an F-statistic of 19.60. The t-statistic demonstrates that the regression coefficient is positive at the 99% level while the F-statistic demonstrates that the coefficient is non-zero at the 99% level and thus has significant explanatory power. The R-squared value of .04 is somewhat low due to the wide spread of RPMs among the low risk projects and the different methods utilized to compute cash flows. Such a distribution among low risk projects is not inconsistent with the AT Group's operations. Many of AT's projects are customer driven development projects where customers commit to the payment in advance so that the expected returns are known in advance and the variances among the pessimistic, realistic and optimistic estimates are quite small. Nonetheless, we are investigating these projects more carefully to improve our understanding of how they can be properly represented in an otherwise risky portfolio.

Our results are depicted in Figure 3, which presents a scatter plot of the portfolio projects in RPM-risk space. It also shows the results of regressing the project RPM value by project risk.

V. Conclusions

The current implementation of the risk metric appears to be appropriate for management use in that it is valid and easily understood. As such, it proves to be a useful tool for assessing the viability of existing projects and evaluation and choice among new projects. It provides a mechanism to measure and managed AT's R&D processes.

Figure 3: Scatter Diagram and Regression Line of RPM vs Risk

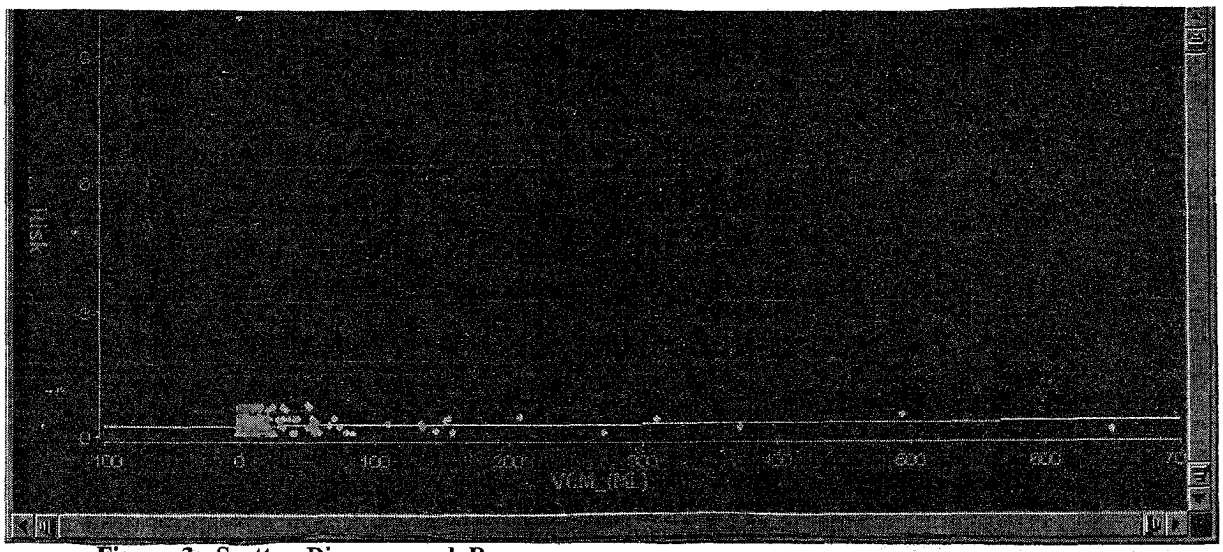


Figure 3: Scatter Diagram and Regression Line of RPM Vs. Risk.

However, given the extensive literature on alternative types of risk, the risk metric appears to be conceptually simplistic. Incorporating more sophisticated measures of risk may reduce the currently high degree of unexplained error variance (low r^2). We are exploring several additional risk evaluation techniques. See figure Three.

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